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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B62D 17/00	A1	(11) International Publication Number: WO 95/18033
		(43) International Publication Date: 6 July 1995 (06.07.95)

(21) International Application Number: PCT/AU95/00001

(22) International Filing Date: 3 January 1995 (03.01.95)

(30) Priority Data:
PM 3200 31 December 1993 (31.12.93) AU

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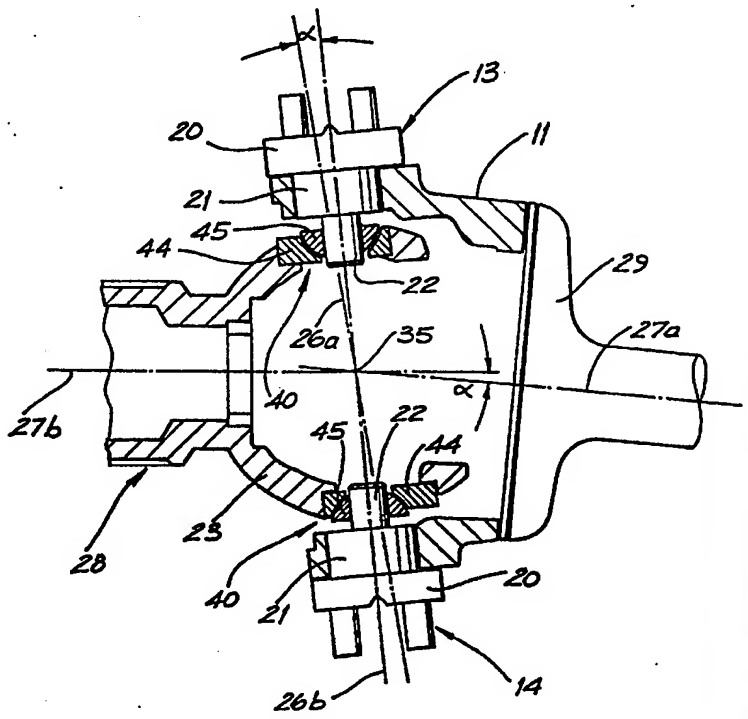
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).

Published
With international search report.

(54) Title: SYSTEM FOR REORIENTING THE KING PIN AXIS OF A KNUCKLE STEERING ASSEMBLY

(57) Abstract

A system for reorienting the king pin axis of a knuckle steering assembly. The assembly comprises a vehicle wheel spindle (11) rotatably connected to an axle tube end (23) by upper and lower king pin stubs (22) seated in bearing means. The bearing means comprise upper and lower eccentric spherical bearings (40) which due to their eccentricity alter the orientation of the king pin. The inventive system may be used with conventional bearing caps or bearing caps with affixed or rotatable offset king pin stubs.



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SYSTEM FOR REORIENTING THE KING PIN AXIS OF A KNUCKLE STEERING ASSEMBLY.

Technical Field

The present invention relates to the adjustment of camber and castor geometry angles in four wheel drive vehicles or other vehicles which employ a solid steerable front axle arrangement in conjunction with a knuckle steering system.

Background Art

Camber, the inward or outward tilt of the wheel at the top, is an important angle of steering geometry which has substantial effects on tyre wear. Incorrect camber will cause a tyre to wear unevenly across the road contact area or tread surface. It is generally accepted that correct camber is of greater importance in the steering-drive vehicle than a steering-non drive vehicle, due to the greater loads to which the steering-drive wheels are subjected. This situation is compounded in four wheel drive vehicles because driving power is transmitted through the steer wheels and, also, the tyres on four wheel drive vehicles have a tendency to be wider than those of conventional vehicles for flotation effect, thus increasing tyre wear with any slight angular difference between inner and outer tyre extremities. With the rapid increase in popularity and acceptance of the radial tyre, a more critical camber specification is essential for optimum tread life. Incorrect camber adjustment can also result in poor steering characteristics. Camber adjustment is often necessary to respond to local conditions and requirements particularly with imported axles where the preferred camber and castor settings differ from the factory specifications. Too wide a factory tolerance, variance in road crown slope and right or left hand driving status all create justification for camber and castor change provisions.

Numerous approaches have been previously adopted to address the problem of poor or unsuitable camber and the consequential effects on tyre life. One of the more primitive responses has been to rotate tyres in an attempt to achieve even tyre wear. Another response has been to bend the axle tube to a desired position thus changing the camber. Neither of these approaches is satisfactory. The former approach does nothing to solve the underlying problem and the latter approach may promote stress failure and misaligned componentry in the tubular axle housing common to most four wheel drive vehicles.

Castor has not generally been adjustable in closed knuckle steering systems. Castor change or variation between sides of a steering axle is required to offset the effects of road crown pull to ensure a straight steering vehicle, provide optimal tyre life, improve vehicle steering, handling and directional control.

U.S. Patent Nos. 4,037,680 and 4,195,862 both disclose a method of adjusting the camber of the front wheels of a four wheel drive vehicle which, although directed to an open steering knuckle arrangement, can be applied to a closed steering knuckle arrangement. A shim of non uniform thickness is inserted between the steering knuckle and the knuckle spindle; thus the orientation of the knuckle spindle can be changed. This system only alters the camber of the steer wheel.

This method is deficient for a number of reasons. To insert the prior art shim requires the removal of the knuckle spindle. This can be a relatively complicated and time consuming task, as most modern four wheel drive vehicles have a free wheeling hub arrangement, which has to be disengaged from the drive stub when the knuckle spindle is removed and re-engaged when the drive spindle is reinstalled. It is desirable to interfere with such components as little as practicable. Also, when the shim

is inserted, rotation of the knuckle spindle and drive stub will occur about different axes because there is a lateral separation between the universal joint at the end of the drive stub and the joint between the steering knuckle and knuckle spindle where the shim is inserted. Consequently shim adjustment of camber results in a slight misalignment of the knuckle spindle and drive stub. As discussed above, the insertion of a shim affects the orientation of the knuckle spindle with respect to the steering knuckle. Due to the thickness of the shim, the knuckle spindle is dislocated laterally with respect to the steering knuckle. Lateral dislocation often requires the fitment of a non-standard thinner circlip or machining of the hub gearing thrust face during reassembly of the free wheel hub mechanism. This dislocation and reorientation of components causes slight relative shifts in positions between the drive stub, axle shaft, steering knuckle, knuckle spindle and axle shaft housing. As a consequence, damage and ongoing maintenance problems related to oil seals and knuckle bearings are not uncommon, due to components being misaligned or dislocated. Often premature damage of intricate parts occurs during fitment of the prior art shim particularly to tab locking washers, wheel bearing nuts, gaskets, screws and free wheel hub componentry.

Problems related to dislocation and disorientation of components are particularly important in the case of vehicles which have front disc brakes. This is because the brake caliper is normally connected to the steering knuckle but the disc is attached to the spindle. Hence the brake caliper and disc become both disoriented and dislocated when camber is adjusted by shim insertion. This situation can be usually corrected by either grinding and filing components or inversely inserting other shims or packers to compensate for this effect, but the

requisite compensating adjustments need to be performed to a high degree of precision and are often performed incompetently, resulting in consequential braking problems in the vehicle.

U.S. Patent Nos. 4,400,007 and 4,252,338 are both based around a simple and easily installed method of adjusting camber and castor for an open steering knuckle arrangement. This previously proposed method is used in an open steering knuckle connected by upper and lower ball joints to a yoke, situated at the end of an axle housing. The conventional concentric housing, that normally receives the ball joint in the yoke, is replaced by a bushing that is angled, skewed or offset to alter the orientation of the ball joint and, therefore, the position on the yoke relative to the steering knuckle. Although this presents minor shortcomings, ball joints are pivotable and can be reoriented. Thus the orientation of the steering knuckle can be varied in relation to the yoke and, consequently, camber and usually castor can be varied. This method is not, however, applicable to closed knuckle arrangements which do not use ball joints but instead use knuckle arms, bearings and bearing caps.

The applicant has previously addressed these problems with the prior art method by providing two alternative techniques for adjusting camber and/or castor in a closed knuckle steering system.

Australian Patent No 595067 to the present applicant relates to a pair of bearing caps for the upper and lower knuckle joints. These bearing caps each have a first cylindrical part adapted to mate with the steering knuckle and a second cylindrical part adapted to rotatably engage the end of an axle tube, the second cylindrical part extending eccentrically from the first part. This eccentricity between the first and second parts alters the position of the steering knuckle relative to the axle tube

to thereby alter the king pin axis and camber of the vehicle wheel.

These bearing caps, however, are quite expensive to produce due to the incorporation of a steering arm in some popular vehicle models.

Australian Patent No 619394 to the applicant provides an alternative solution by replacing the conventional upper and lower knuckle joint bearings of a closed knuckle steering system with upper and lower eccentric ring/bearing assemblies. This provides a means to vary camber and/or castor angle. Each ring has an outer surface coaxial with the first king pin axis and an inner surface coaxial with a second king pin axis. The eccentric rings are inserted into the axle tube end and the bearing is then fitted into the respective eccentric rings to receive the king pin studs extending from the upper and lower bearing caps. The desired, calculated, eccentric location of the upper and lower bearings reorients the king pin axis to alter the camber and/or castor of the vehicle steer/drive wheel.

These eccentric ring/bearing assemblies may be used to alter camber and/or castor of the vehicle wheel. As will be understood by persons skilled in the art, for camber adjustment rotation of the king pin axis occurs in a plane oriented at right angles to a plane in which the king pin axis is rotated for castor adjustment.

While an eccentric ring/bearing assembly is very effective for such adjustment of camber/castor, problems may occur if the system is not installed competently. If the bearing is not seated properly in the eccentric ring, or misaligned on installation, cracking or chipping may occur.

Additionally, in this system a slightly reduced diameter bearing is required to fit the eccentric ring, although this slightly reduced bearing has a similar

rolling contact.

In an effort to overcome or at least reduce the problems of the prior art it is proposed to provide a method for rearranging the king pin axis of a knuckle steering system which, at least in the preferred embodiments, provides an improved, reliable and simpler means for altering camber and/or castor of a vehicle wheel.

Disclosure of the Invention

Accordingly, in a first aspect the present invention provides a system to reorient the king pin axis of a knuckle steering assembly, said assembly comprising a steering knuckle carrying a wheel spindle and rotatably connected to an axle tube by upper and lower king pins received in upper and lower bearing means respectively, said system comprising an eccentric spherical bearing as one of the upper or lower bearing means, said spherical bearing having a circumferential outer surface and a circumferential inner surface with an axis of rotation eccentric to the outer surface wherein the outer surface of the spherical bearing is adapted to engage either the end of the axle tube or the steering knuckle and the inner surface of the spherical bearing is adapted to rotatably receive a king pin, the eccentricity of the spherical bearing altering the orientation of said king pin axis relative to said axle tube end.

The term "eccentric spherical bearing" as used herein includes within its scope any spherical bearing in which the inner and outer circumferential surfaces are eccentric to each other including an eccentric spherical bearing ring or bushing with spherical bearing member seated therein; a concentric spherical bearing ring or bushing with an eccentric spherical bearing member seated therein; or a concentric spherical bearing ring or bushing and member fitted in an eccentric ring or sleeve.

In the first embodiment, said system comprises a pair of complementary eccentric spherical bearings as both the upper and lower bearing means.

In another embodiment, one of the upper or lower bearing means is an eccentric spherical bearing and the other of the upper or lower bearing means is a concentric spherical bearing.

It is also envisaged that the present inventive eccentric spherical bearings may be used in conjunction with conventional upper or lower bearing caps or with bearing caps with fixed offset king pin stubs or with rotatable offset king pin stubs.

In another aspect, the present invention comprises a system for rearranging the king pin axis of a knuckle steering assembly, said assembly comprising a steering knuckle and a pair of upper and lower king pins to rotatably connect said steering knuckle to an axle tube end of said knuckle steering system, said system comprising a pair of complementary upper and lower eccentric spherical bearings, each spherical bearing having an outer circumferential surface locatable in said axle tube end and an inner circumferential surface adapted to receive one of said king pins, said outer surfaces being coaxial with a first king pin axis and said inner surfaces being coaxial with a second king pin axis when said spherical bearings are in situ, said first and second king pin axes being non-coaxial.

The present invention further provides an improvement in a closed knuckle steering assembly comprising a steering knuckle carrying a wheel spindle and rotatably connected to an axle tube end by upper and lower king pins received in upper and lower bearing means respectively, the improvement comprising providing at least one eccentric spherical bearing to replace one of the upper and lower bearing means, said spherical bearing having a

circumferential outer surface and a circumferential inner surface with an axis of rotation eccentric to the outer surface wherein the outer surface of the spherical bearing is adapted to engage either the end of the axle tube or the steering knuckle and the inner surface of the spherical bearing is adapted to rotatably receive a king pin, the eccentricity of the spherical bearing altering the orientation of said king pin axis relative to said axle tube ends.

A key advantage of using spherical bearings as compared to the prior art is the fact that the eccentric spherical bearings of the present invention do not require any angular displacement. To explain, as discussed previously when reorienting the king pin axis it is preferable that the king pin stubs are coaxial with this new king pin axis. If the king pin stubs are even slightly misaligned, high side thrust can be applied to which may cause conventional roller bearings to wear unevenly and in extreme cases, collapse. The eccentric spherical bearings of the present invention, on the other hand, are self aligning and do not require any reangling of the king pin stubs or bearing rings.

A further advantage arises due to the larger frictional contact area provided by the eccentric spherical bearings of the present invention as compared to conventional roller bearings. Conventional roller bearings have difficulty in coping with the high thrust and impact load forces applied by a knuckle steering assembly. This causes "brinnelling" or indents created by the rollers contacting and wearing the outer bearing ring or bushing generally in the "ahead" steering position. This leads to wheel shimmy effects, looseness, loss of bearing preload and notchy steering. Conventional roller bearings generally have a high maintenance and servicing requirement. The applicants have found that when used in

knuckle steering assemblies, the eccentric spherical bearings of the present invention exhibit a much lower and more even wear rate as compared with conventional roller bearings thereby providing a much longer service life, improved lubrication, and less maintenance.

Indeed, it has been found that as the eccentric spherical bearings are used in the knuckle steering assembly, the wear is infinitesimal and spread evenly over the mating surfaces of the bearing member and bearing ring or bushing providing a dramatic improvement as compared to conventional roller bearings.

It will therefore be appreciated by those skilled in the art that the present invention simultaneously provides a number of advantages as compared to the prior art. Not only does it provide an effective, reliable means for adjusting camber and/or castor of a knuckle steering assembly but, as it avoids the need for reangling i.e. machining of the king pins or bearing rings to align with the new king pin axis, it is also cheaper and easier to install as compared to prior art methods. Still further, the present inventive system decreases side load exerted on the upper and lower bearing means, reduces wear, increases service life and maintenance intervals while at the same time, due to the higher frictional surface area of the eccentric spherical bearings, reduces wheel shimmy and steering shake and aids smoother steering forces.

To adjust camber of a vehicle wheel assembly the king pin axis is rotated in a vertical plane which runs through the axle axis. To decrease camber, the king pin axis is rotated to bring the top of the wheel toward the vehicle. An increase in camber will rotate the king pin axis such that the top of the wheel is forced outwardly away from the vehicle. By appropriate positioning of one or two eccentric spherical bearings at the upper and lower knuckle joints of the knuckle steering assembly the king

pin axis may be rotated to either increase or decrease camber as desired.

For example, if we consider the left hand front steering/driving wheel, camber may be reduced by replacing the lower conventional roller bearing with an eccentric spherical bearing, the axis of rotation of the eccentric spherical bearing being offset to the vehicle wheel side of the assembly. This eccentricity will in effect rotate the king pin axis counter-clockwise, when looking from the front of the vehicle, to "kick out" the bottom of the wheel and bring the top of the wheel towards the vehicle. Such rotation of the king pin axis may also be accomplished by replacing the upper conventional roller bearing with an eccentric spherical bearing with the axis of rotation of the upper eccentric spherical bearing being offset to an interior side of the original king pin axis.

In respect to adjustment of castor it will be understood by the person skilled in the art that for castor adjustment rotation of the king pin axis occurs in a plane oriented at right angles to a plane in which the king pin axis is rotated for camber adjustment. In other words, to adjust castor, the king pin axis is rotated in a vertical plane extending at right angles to the axle tube axis.

Accordingly, by orienting the eccentric spherical bearings either forwardly or rearwardly of the original king pin axis, this king pin axis may be rotated to adjust castor.

To explain, if we view a vehicle wheel from side on, castor is adjusted by rotating the king pin axis either clockwise or counter-clockwise. By replacing, say, the lower conventional roller bearing with the inventive eccentric spherical bearing with the axis of rotation of the eccentric spherical bearing being offset toward the rear of the vehicle, relative to the original king pin

axis, the king pin axis is effectively rotated anti-clockwise and castor is reduced. A similar adjustment may be made by placing an eccentric spherical bearing in the upper knuckle joint with the axis of rotation offset toward the front of the vehicle.

Such a castor adjustment means allows the steering assembly to be altered to provide an offset or self aligning force to counter the pull effect of high road crown surfaces where a tendency for the vehicle to ease or pull to the downward or outer side of the road is experienced. This phenomenon is found particularly with vehicles manufactured in countries where the steering geometry settings are more suited to flat road surfaces, or to suit the driving status on the opposite side of the road in which the castor difference is opposite to that required in the final country of vehicle destination.

Incorrect castor or castor bias insufficient to counter high crowned road surfaces produces constant driver correction to maintain vehicle direction, produces unsafe driving effects, driver fatigue and in addition the opposing force applied by the driver offsets the steering tyres to some degree to that of the vehicle thrust angle creating a tyre scrub effect. These aforementioned steering geometry related problems are not being addressed with the attention deserved by some manufacturers.

Referring back to camber principles, the camber angle can be minimally and within limits used to help offset road crown pull by applying a difference in camber between sides of the four wheel drive vehicle described herein by application of the theory that a tilted wheel will roll around the apex of its cone. However camber difference in some four wheel drive vehicles is insufficient to correct road crown pull effect. The principles outlined have been minimally addressed on U.S.A. road conditions in particular which have low road crown pitches and left hand

drive status.

In another embodiment, the present invention provides a means to vary the relationship of castor and/or camber on one side of a vehicle as compared to the other side, thus providing a difference or spread of camber and/or castor.

It would normally be customary to undergo a castor change only on one side of the axle by fitment of the inventive system, such arrangement being produced and calculated to vary the castor by a predetermined amount.

The present invention further provides a means for altering the steering geometry of a vehicle from its factory settings to those required for the road conditions applying in the country of use.

In another embodiment, the upper and lower eccentric spherical bearings are preferably 180° out of phase.

Brief Description of the Drawings

The present invention will now be described by way of example only with reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view of a conventional knuckle steering assembly;

Figure 2 is a cross-sectional view of an axle tube end incorporating a means to vary camber according to a first embodiment of the present invention;

Figure 3 is a cross-sectional view of a closed knuckle steering assembly according to another embodiment of the present invention;

Figure 4 is an end elevational view of an axle tube incorporating means to vary castor according to another embodiment of the present invention;

Figure 5 is a plan view of an eccentric spherical bearing according to yet a further embodiment of the present invention,

Figure 6 is a plan view of an eccentric spherical

bearing according to still a further embodiment of the present invention, and

Figure 7 is a removable chart or dial to assist in reorientation of the king pin axis of a knuckle steering assembly.

Best Mode for Carrying out the Invention

Referring firstly to Figure 1, this closed knuckle steering assembly it can be seen that steering knuckle 11 carries wheel spindle 29 and is rotatably connected to the end 23 of axle tube 28 by bearing caps 13 and 14.

These bearing caps each comprise a backing body 20 first cylindrical part 21 and second cylindrical part or king pin 22. The first cylindrical part 21 engages the steering knuckle 11 with the second cylindrical part of king pin 22 extending therefrom to engage bearing means 24 provided in axle tube end 23. These bearing means 24 provide for rotation of king pins 22. Insertion of a shim 12 of non-uniform thickness between the exterior side of the steering knuckle 11 and wheel spindle 29 is one of the less successful prior art methods of varying camber only.

In this embodiment the king pins 22 extend from bearing caps 13, 14 to engage conventional roller bearings. Other steering assemblies provide bushings for bearing means 24 or the king pins 22 extend from the axle tube end 23 into bearing means held by the steering knuckle 11. The present inventive system is suitable for all such steering assemblies.

It can be seen in the conventional arrangement of Figure 1 that bearings 24 and king pins 22 are coaxial about king pin axis 26a. For the sake of clarity in this illustration, a horizontal axis 27 is shown representing the coaxial alignment of axle tube 28, steering knuckle 11 and wheel spindle 29.

In Figure 2, an axle tube 28 is shown in cross-section.

According to the present invention at least one of the bearing means 24 (shown in Figure 1) is an eccentric spherical bearing 40 as exemplified in Figures 5 and 6. As shown in Figure 5, the bearing 40 may comprise an eccentric spherical bearing ring or bushing 44 in which is seated a hemispherical bearing member 45. The outer circumferential surface of a ring or bushing 44 has an axis of rotation 41. Hemispherical bearing member has an aperture which receives the king pin stub of the steering assembly. The inner circumferential surface of this aperture has an axis of rotation 42 which is slightly offset relative to axis 41 thereby providing an inner circumferential surface eccentric to the outer circumferential surface. Alternatively, and as shown in Figure 6, the hemispherical bearing member 45 may be eccentric as compared to the eccentric ring or bushing 44 of Figure 5. But once again, the outer circumferential surface is centered around axis 41 and the inner circumferential surface is centered around axis 42 which is slightly offset relative to axis 41. The king pin axis is normally positioned along line 26a this being coaxial with the apertures formed in the end of axial tube 23 for receiving conventional roller bearings. According to the present invention, the conventional roller bearings may be replaced with eccentric spherical bearings which reposition the king pin axis by angle α to axis 26b.

In this embodiment both upper and lower conventional roller bearings are replaced by eccentric spherical bearings 40, however, as previously discussed camber and/or castor adjustment can be effected by replacing only one of the upper or lower roller bearings with an inventive eccentric spherical bearing 40.

As can be seen in Figure 2, the outer circumferential surfaces of the eccentric bearings 40 are coaxial with original king pin axis 26a. The inner circumferential

surface of the eccentric spherical bearings are, however, coaxial with new king pin axis 26b.

When installed, as shown in Figure 3, the king pins 22 of upper and lower bearing caps 20 will engage the eccentrically located hemispherical bearing members 45 to effectively rotate the steering knuckle 11, relative to the axle tube end 23. Accordingly, the axis of symmetry 27a of the spindle is rotated by angle α relative to the axis of symmetry 27b of the axle tube end. As the steering knuckle 11 and wheel spindle 29 are rigidly connected both components are rotated through an angle α equal to the change in king pin axis so that the steering wheel camber will have been altered by angle α .

It should also be noted that the steering knuckle 11 and spindle 29 are rotated about point 35, this point coinciding with the universal joint (not shown) connecting the axle shaft and drive stub (also not shown). As this intersection point 35 is in exactly the same position before and after rotation of the king pin axis (see Figure 1), no dislocation of the axle shaft or drive stub occurs if camber is adjusted in the manner proposed.

Furthermore, as the relative orientation between the spindle 29 and steering knuckle 11 does not vary during camber adjustment the position of the brake caliper (not shown) connected to the steering knuckle 11 will not be changed with respect to the brake disc (also not shown) mounted on the spindle. This means that camber adjustment may be carried out without the need to machine components or insert compensating shims.

Either or both of the conventional roller bearings 24 shown in Figure 1 may be replaced by the inventive eccentric spherical bearings 40 such that king pins 22 mate with the inner circumferential surface of hemispherical bearing member 45.

In a preferred embodiment of the present invention,

if only one of the bearing means is an eccentric spherical bearing 40 the other bearing means may be a concentric spherical bearing in order to assist correct alignment of the king pins 22 along the new king pin axis 26b. Unlike previous methods of altering the king pin axis, re-angling of bearings 40, or king pins 22 to match the altered camber or castor is unnecessary.

In addition to the aforementioned camber adjustment, it is envisaged that the present invention may also be used to adjust castor in a knuckle steering system.

For castor variation, referring now to Figure 4, the eccentric spherical bearings are installed such that the outer circumferential surface of eccentric ring member 44 is coaxial on original king pin axis 46a.

When the bearing caps 13 and 14 are installed with king pins 22 inserted in the inner circumferential surface of hemispherical bearing member 45, the axis of symmetry will be rotated to position 46b i.e. by an angle β

It will be apparent to persons skilled in the art that for castor adjustment rotation of the king pin axis occurs in a plane orientated at right angles to the plane through which the king pin axis is rotated for camber adjustment.

In the preferred embodiments of the eccentric spherical bearing shown in Figures 5 and 6, an indexing mark 50 is marked on ring 44 to assist correct positioning of the bearing 40 in the axle tube end. It is preferred that the upper and lower eccentric spherical bearings introduce eccentricities of equal and opposite magnitude, i.e. 180^{o} out of phase to rotate the king pin axis. Such a marking 50 is also of assistance in ensuring precisely opposite orientation and indicates if a positive or negative adjustment is being made. Further this indexing mark may be used in conjunction with a clock face type diagram as shown in Figure 7 to correctly position bearings 40, relative to each other and axle tube end 23

as follows.

Installation of the eccentric spherical bearings 40 and subsequent variation of camber and/or castor is best carried out by an appropriately skilled mechanic. Referring back to Figure 1, although bearing caps 13 and 14 fit firmly into steering knuckle 11 and axle tube 23, they may be easily removed. In practice, following removal of tie rod end, the nuts holding down the bearing caps are removed and the caps are disengaged from the steering knuckle 11. Once the bearing caps are removed with wiper seals and free wheel hub locating circlip, the steering knuckle 11 may be simply disengaged from axle tube ends 23. Once the steering knuckle 11 has been disconnected from the end 23 of axle tube 28, the chart or clockface diagram shown in Figure 7 is placed at the position where it is is intended to install the eccentric spherical bearing. The chart must be aligned correctly relative to the vehicle. As shown in the diagram if we are considering an Australian right hand vehicle the chart should be positioned such that the front of the vehicle is in the 3 o'clock direction and the right hand side axle of the vehicle is in the 12 o'clock direction when the chart is placed on top of the axle tube end. In such a position, a skilled operator may easily increase or decrease the camber or castor of a vehicle as follows. Let us assume that the vehicle has been tested and an increase in camber of 0.75^{o} and a decrease in castor of 1.5^{o} is required. The operator will first select a particular sized eccentric spherical bearing. For this example let uspresume that the eccentric spherical bearing has a 2.25^{o} offset. In other words, for a camber increase of 0.75^{o} the camber should be + 1/3 the size of the ring, andfor a castor decrease of 1.5^{o} the castor should be -2/3 the size of the ring. This configuration corresponds to the 10 o'clock position shown on the dial.

The operator then simply places the eccentric spherical bearing with index mark at the 10 o'clock position prior to tapping the eccentric spherical bearing into position. Alternatively, the skilled technician may make a reference mark with a pen, tape or the like on the axle tube end at the 10 o'clock position, remove the chart and install the eccentric spherical bearing such that its index mark is aligned with the mark placed on the axle tube end by the skilled technician.

Such a procedure easily allows a skilled operator to increase or decrease the camber and/or castor of the steering assembly. Preferably, a similar chart is placed on the bottom of the axle tube end to correctly install the lower eccentric spherical bearing. Most preferably this lower chart of 180^{o} out of phase so that the installed eccentric spherical bearings are similarly 180^{o} out of phase thereby avoiding any lateral displacement of the CV joint and ensuring optimum clearance between the various components of the knuckle steering assembly.

As mentioned above, an alternative embodiment of the eccentric spherical bearing 40 may be provided by an eccentric ring containing a concentric spherical bearing. To explain, such an eccentric ring has an inner circumferential surface adapted to receive the outer circumferential surface of a concentric spherical bearing. The inner circumferential surface of the eccentric ring has an axis which is offset from the axis of the outer circumferential surface so that in effect the aperture in the concentric spherical bearing adapted to receive the king pin 22 is offset relative to the outer circumferential surface of the eccentric ring.

While the embodiment shown in Figures 1-5 have bearing caps 13 with coaxial king pins 22 it is also envisaged by the present applicant that the inventive king

pin axis adjustment mechanism may also be used with bearing caps which have fixed offset king pins or rotatable king pins.

To explain, a previous mechanism for altering the camber of a steering knuckle involves removal of the original equipment bearing caps and replacement with bearing caps which have fixed offset king pins so that upon reassembly the king pin axis is rotated slightly to match the new offset position.

Bearing caps may also have a rotatable offset king pin assembly such that upon installation the king pin axis may be externally altered by rotation of a shaft extending through the backing plate of the bearing cap to the offset king pin. Such an externally adjustable mechanism allows fine tuning of at least camber.

In another embodiment of the present invention such bearing caps with fixed offset king pins or rotatable offset king pins may be used in conjunction with the inventive spherical bearings at either or both of the upper and lower knuckle joints to alter the king pin axis and at least camber of the steering knuckle assembly.

In still a further embodiment, the inventive system may be used in knuckle steering assemblies which have king pin stubs or posts fixed to the axle tube end.

To explain, in some 4-wheel drive or truck steering assemblies the axial tube end is formed with the king pin posts extending radially therefrom to engage the steering knuckle. Such king pin stubs or posts are usually welded to the axle tube end.

According to the present invention, the king pin axis of such assemblies may be reoriented by providing a concentric spherical bearing ring or bushing adapted to seat in a steering knuckle with an eccentric hemispherical bearing member adapted to receive a king pin post. When the steering knuckle is refitted to the axle tube end, the

eccentricity of the hemispherical bearing member alters the orientation of the steering knuckle relative to the axle tube end to alter camber and/or castor of the steering assembly.

The eccentric spherical bearing is shown in Figure 6 is particularly suitable for this purpose. In this bearing, the ring or bushing is concentric.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

CLAIMS:

1. A system to reorient the king pin axis of a knuckle steering assembly, said assembly comprising a steering knuckle carrying a wheel spindle and rotatably connected to an axle tube by upper and lower king pins received in upper and lower bearing means respectively, the system comprising an eccentric spherical bearing as one of the upper and lower bearing means, said spherical bearing having a circumferential outer surface and a circumferential inner surface with an axis of rotation eccentric to the outer surface wherein, the outer surface of the spherical bearing is adapted to engage either the end of the axle tube or the steering knuckle and the inner surface of the spherical bearing is adapted to rotatably receive a king pin, the eccentricity of the spherical bearing altering the orientation of said king pin axis relative to said king pin axle tube end.

2. A system as claimed in claim 1 wherein both the upper and lower bearing means are eccentric spherical bearings.

3. A system as claimed in claim 2 wherein the upper eccentric spherical bearing is 180^{o} out of phase relative to the lower eccentric spherical bearing.

4. A system as claimed in claim 1 wherein one of the upper or lower bearing means is an eccentric spherical bearing and the other of the upper or lower bearing means is a concentric spherical bearing.

5. A system as claimed in any one of claims 1-4 wherein said upper and/or lower king pins are provided by bearing caps with concentric or fixed offset king pin stubs.

6. A system as claimed in any one of claims 1-4 wherein said upper and/or lower king pins are provided by bearing caps with rotatable offset king pin stubs.

7. A system for rearranging the king pin axis of the knuckle steering assembly, said assembly comprising a steering knuckle and a pair of upper and lower king pins

to rotatably connect said steering knuckle to an axle tube end of said knuckle steering system, said system comprising a pair of complementary upper and lower eccentric spherical bearings each spherical bearing having an outer circumferential surface locatable in said axle tube end and an inner circumferential surface adapted to receive one of said king pins, said outer surfaces being coaxial with a first king pin axis and said inner surfaces being coaxial with a second king pin axis when said spherical bearings are in situ, said first and second king pin axes being non-coaxial.

8. A system as claimed in claim 7 wherein said upper and/or lower king pins are provided by bearing caps with concentric or fixed of said king pin stubs.

9. A system as claimed in claim 7 wherein said upper and/or lower king pins are provided by bearing caps with rotatable of said king pin stubs.

10. In a closed knuckle steering assembly comprising a steering knuckle carrying a wheel spindle and rotatably connected to an axle tube end by upper and lower king pins received in upper and lower bearing means respectively, the improvement comprising providing at least one eccentric spherical bearing for one of the upper and lower bearing means, said spherical bearing having a circumferential outer surface and a circumferential inner surface with an axis of rotation eccentric to the outer surface wherein the outer surface of the spherical bearing is adapted to engage either the end of the axle tube or the steering knuckle and the inner surface of the spherical bearing is adapted to rotatably receive a king pin, the eccentricity of the spherical bearing altering the orientation of said king pin axis relative to said axle tube ends.

11. A closed knuckle steering assembly as claimed in claim 10, the improvement comprising providing an

eccentric spherical bearing for one of the upper and lower bearing means and providing a concentric spherical bearing for the other of the upper and lower bearing means.

12. A closed knuckle steering assembly as claimed in claim 10 the improvement further comprising providing eccentric spherical bearings for both the upper and lower bearing means.

13. A closed knuckle steering assembly as claimed in claim 12 the improvement further comprising positioning the upper eccentric spherical bearing 180^{o} out of phase relative to the lower eccentric spherical bearing.

14. A closed knuckle steering assembly as claimed in any one of claims 10-13 the improvement further comprising providing with bearing caps having fixed or rotatable offset king pin stubs for the upper and lower king pins.

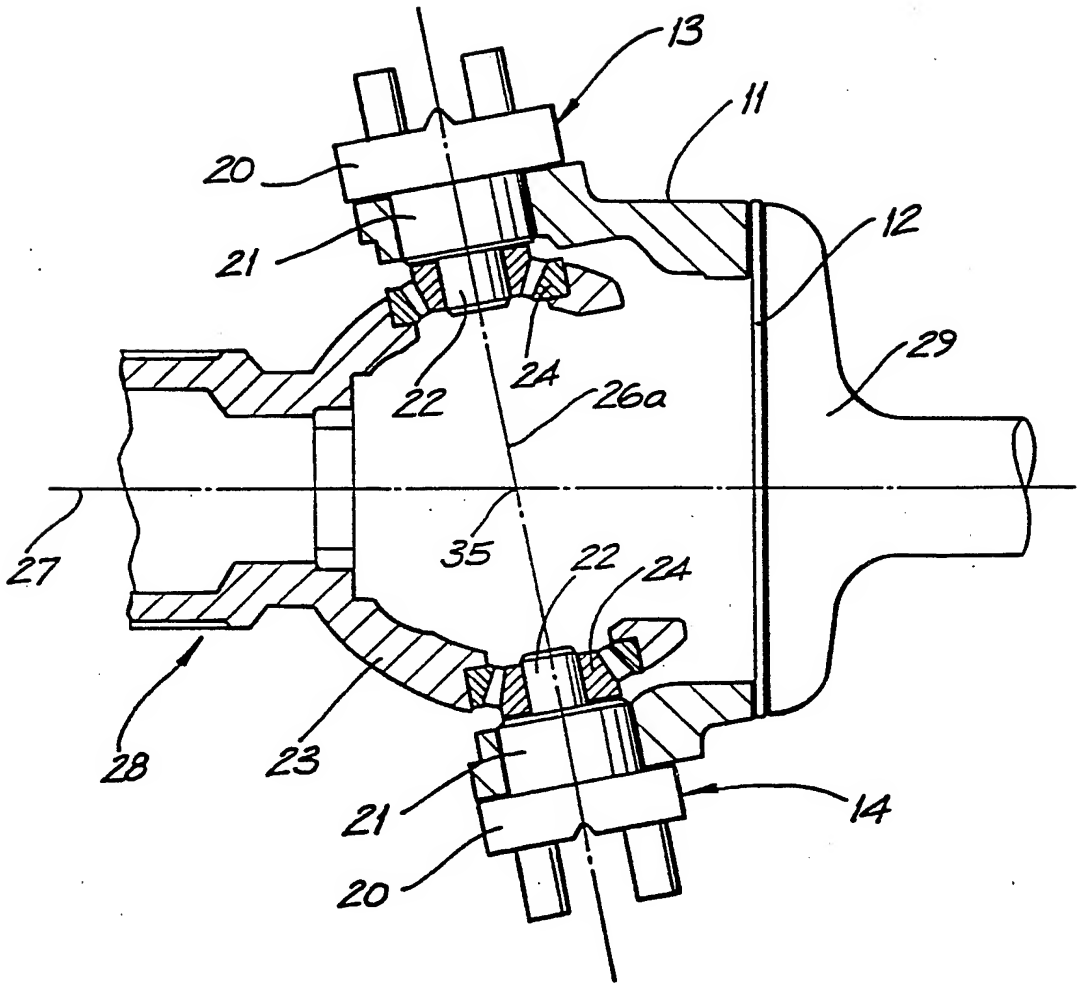
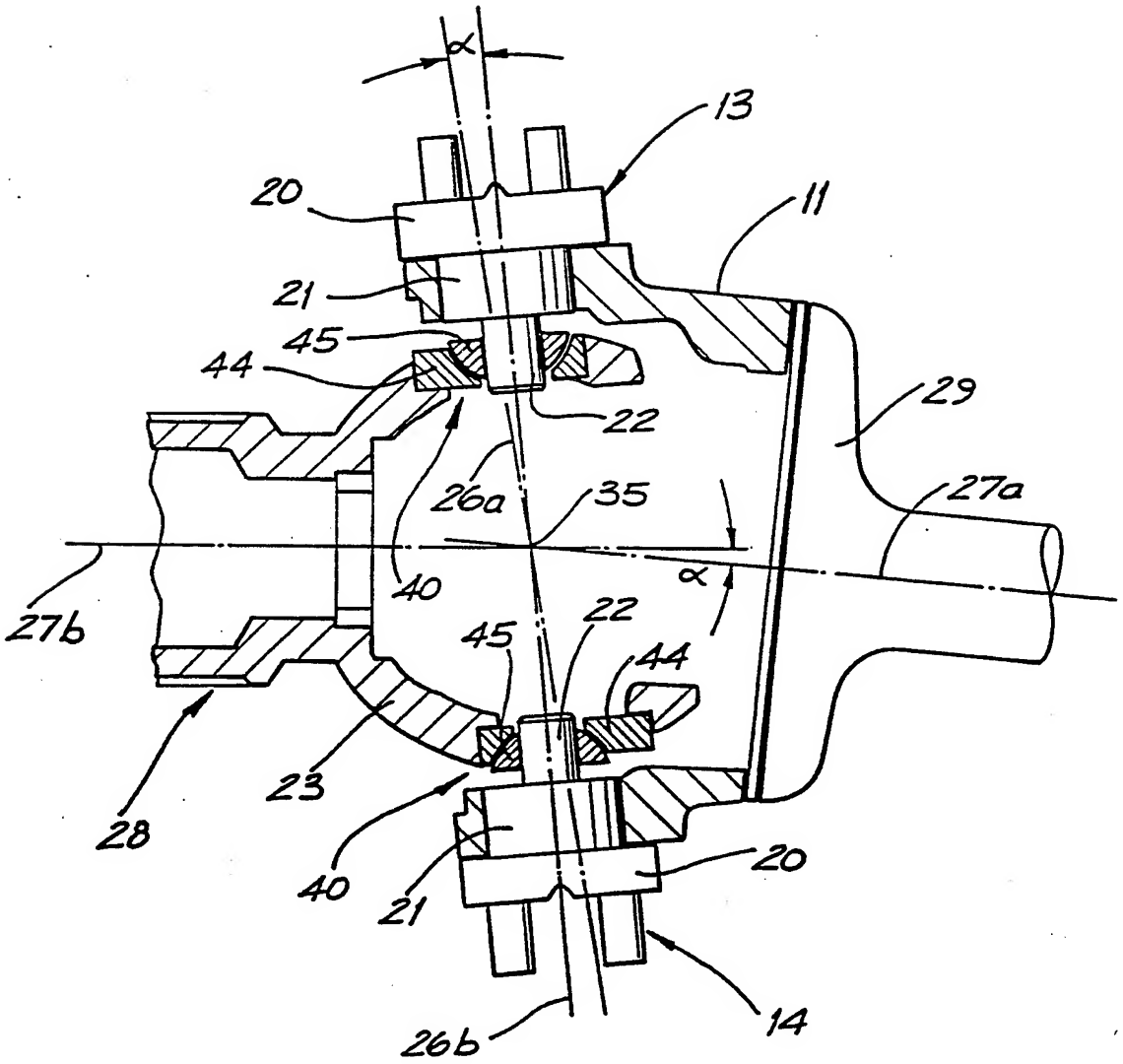


FIG. 1


α
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26a
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27a
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α
27b
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20
14
26b

FIG. 3

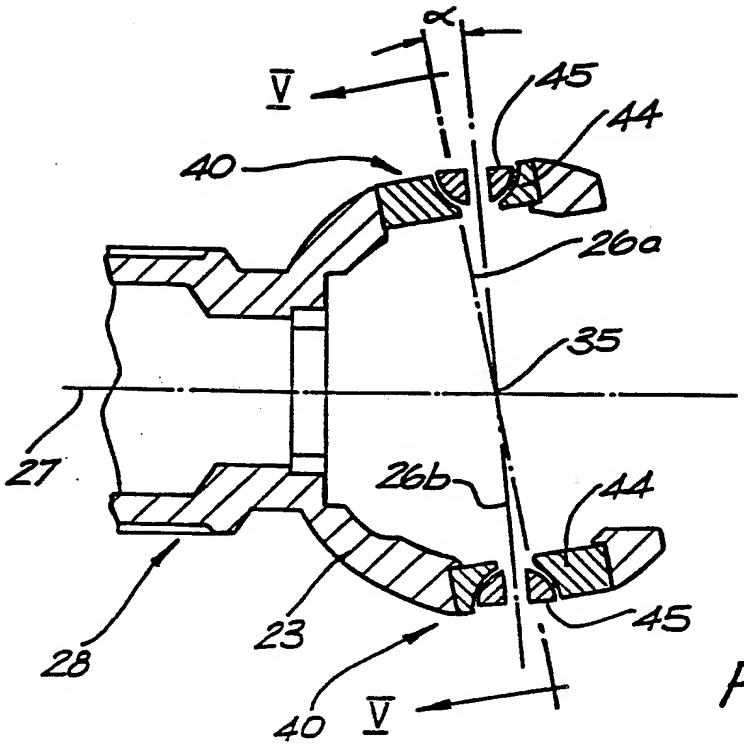


FIG. 2

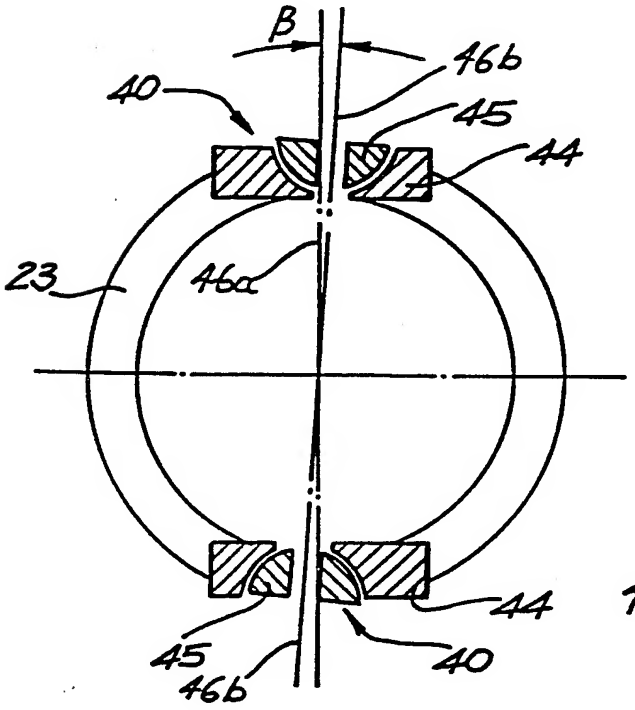


FIG. 4

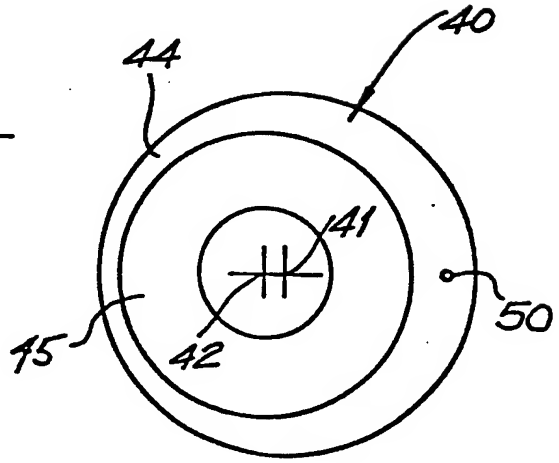


FIG. 5

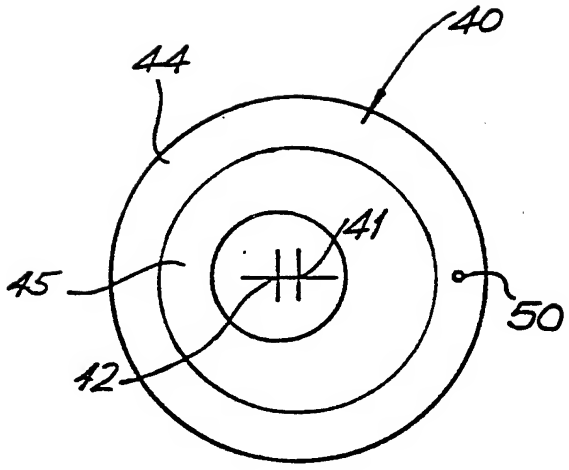
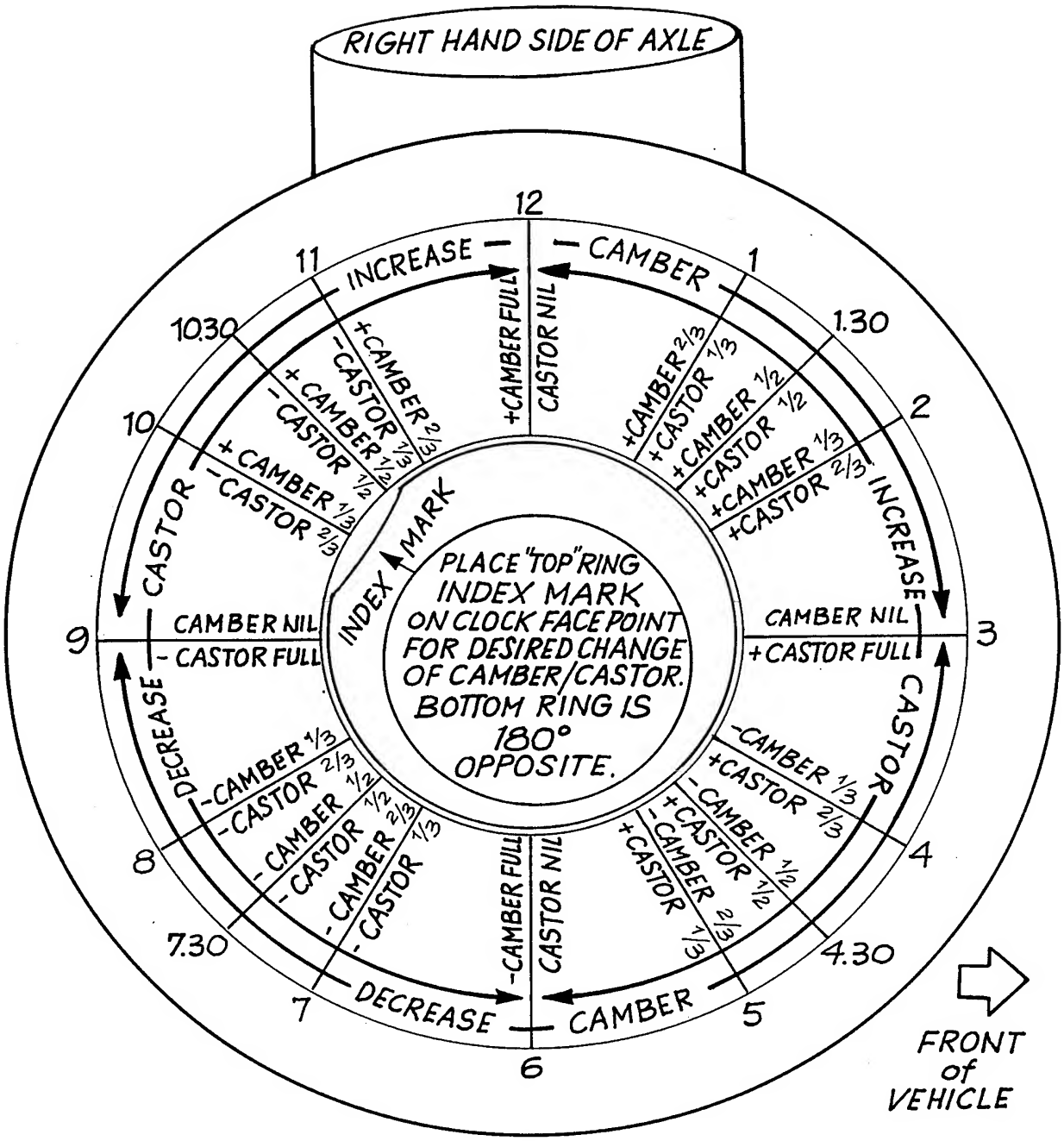


FIG. 6


RIGHT HAND SIDE OF AXLE
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3
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7
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8
9
10
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11
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INCREASE + CASTOR
CAMBER NIL
+ CASTOR FULL
DECREASE + CAMBER
DECREASE - CASTOR
CAMBER NIL
- CASTOR FULL
DECREASE - CAMBER
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-CASTOR 1/3
-CAMBER FULL
CASTOR NIL
+CASTOR 1/3
-CAMBER 2/3
+CASTOR 1/2
-CAMBER 1/2
+CASTOR 2/3
-CAMBER 1/3
INDEX MARK
PLACE "TOP" RING INDEX MARK ON CLOCK FACE POINT FOR DESIRED CHANGE OF CAMBER/CASTOR. BOTTOM RING IS 180° OPPOSITE.
FRONT of VEHICLE

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 95/00001

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[6] B62D 17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: B62D 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	AU,B,5227/90 (619394) (REILLY et al) 2 August 1990 (02.08.90) page 11, line 33 - page 13, line 6 and figures 4-6	1-14
Y	AU,B,12583/88 (600558) (NEWCASTLE TRUCK [& BUS] WHEEL ALIGNMENT PTY LTD) 1 September 1988 (01.09.88) page 4, line 5 - page 5, line 10	1-14
P,X	US,A,5316332 (INGALLS) 31 May 1994 (31.05.94) column 3, lines 28-47	1-14

[X] Further documents are listed in the continuation of Box C.

[ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 March 1995 (28.03.95)	5 APRIL 1995 (05.04.95)
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	Authorized officer for C.M.WYATT Telephone No. (06) 2832538

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	AU,B,55860/90 (620516) (PRO-AXLE AUSTRALIA PTY LIMITED) 6 December 1990 (06.12.90) page 2, line 28 - page 3, line 3	
A	US,A,4252338 (INGALLS et al) 24 February 1981 (24.02.81) column 3, line 30 - column 4, line 30	
A	US,A,4795187 (INGALLS) 3 January 1989 (03.01.89) column 3, line 16 - column 4, line 33	
A	US,A,4836574 (INGALLS) 6 June 1989 (06.06.89) column 2, line 65 - column 3, line 32	
A	US,A,4231588 (WOTTON et al) 4 November 1980 (04.11.80) column 3, lines 18-37	